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# Biogeoclimatic Ecosystem Classification of Non-forested Ecosystems in British Columbia

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BRITISH COLUMBIA

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William MacKenzie

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Non-forested ecosystems are an important part of British Columbia's landscape and biological diversity. Plant community composition and vegetation structure of these ecosystems stand in contrast to the forests that are typical of much of British Columbia. These non-forested habitats supply critical life history requirements for many plant and animal species.

Biogeoclimatic Ecosystem Classification (BEC) has been applied extensively in characterizing forested ecosystems in British Columbia. However, the focus has largely been on mature forest stands; non-forested ecosystems have received relatively little classification effort in British Columbia. However, with landscape planning initiatives and extensive ecosystem mapping work over the last decade, the need for a working classification of non–timber-producing ecosystems has become a priority.

The working site units of BEC, site series and site associations, are defined and identified in part by communities of plant species. Therefore, BEC relies on well-trained, knowledgeable users for proper application. The site series defines units that reflect the appropriate level of detail for the goals of forest management. However, for non–timber-producing ecosystems, a broader perspective is often better suited for management applications, and specific species information is less important at this level. A hierarchical classification system that generalizes site associations into functionally broader units requiring less detailed knowledge of species identification would therefore have the double advantage of appropriateness of scale and ease of application by non-technical users.

A hierarchy of broader units of this nature for wetlands and related ecosystems is presented in the *Wetlands of British Columbia* (MacKenzie and Moran 2004). The report that follows formalizes these hierarchical units into the BEC system and extends the system to all naturally occurring non-forested ecosystems in British Columbia, including alpine, subalpine krummholz and shrubland, grassland, rock outcrop and talus, beach and rocky headland, and persistent disclimax ecosystem.

## 1.1 Objective

This report formalizes new higher-level site units for BEC. These broader units of the hierarchy retain the BEC concept of vegetation as an integrator of environmental conditions; but, at a broader functional level with less focus on species. The site-based hierarchy is not intended to replace the upper levels of the vegetation hierarchy but to provide a comparable hierarchical framework for the BEC site component, expanding it to allow description of functionally broader but ecologically consistent units.

These upper site component levels provide the following benefits:

- facilitate an understanding of broader ecological relationships
- provide broad ecosystem units for applications not requiring site series– or site association–level detail
- provide a classification unit where more specific information required for association designation is not currently available
- assist in communicating ecology and ecological management principles to non-technical users
- provide a framework and connotative coding system for organizing and presenting site association information

Some general principles for the creation of units and codes were considered:

- Higher-level units should group ecologically similar ecosystems;
- Development of units reflects a consistent methodology;
- Unit names should employ common language, where possible;
- Units should facilitate understanding by a non-technical audience;
- Site groups should ideally contain a modest number of site classes; and
- A priority of class designation should be constructed to aid placement of ecosystems that might meet the definitions of two or more site units.

## 2 BIOGEOCLIMATIC ECOSYSTEM CLASSIFICATION FRAMEWORK

### 2.1 Components of the Biogeoclimatic Ecosystem Classification System

Biogeoclimatic Ecosystem Classification has been used to improve resource management in British Columbia since 1976. The objective of the BEC program has been to develop a "permanent," land-based, ecological classification to organize our knowledge of ecosystems and serve as a framework within which to manage resources. The program has five main objectives:

1. identify and map regions of similar bioclimate (biogeoclimatic zone, subzone, variant) in British Columbia;
2. describe major ecosystems within each of the biogeoclimatic units;
3. provide tools for field identification of classification units;
4. develop management interpretations for site units or groups of site units; and
5. promote the concept of the ecosystem as a fundamental unit of resource management.

BEC is an integrated classification comprised of three component hierarchies: vegetation, site, and zonal (Figure 1). The system is focussed on the site component; it aims to create units from sites with similar biological potential. BEC defines this potential at the association and series level by mature (climax) plant communities (vegetation hierarchy), which reflect both overarching climatic factors (zonal hierarchy) and stand-level site and soil conditions. The site series represents an ecological attractor (Hauessler 2011) for a specific climate/site condition towards which vegetation will develop in a reasonably predictable manner over time.

The units of the vegetation and zonal components of BEC are defined by Meidinger and Pojar (1991). The units of the vegetation hierarchy are based on plant community species similarity throughout, and the resulting high-level units generally describe floristically related biogeographic zonal vegetation or groups of ecosystems with strong site-level ecological factors. This is common for other plant community–based classifications (e.g., Rodwell et al. 2002; FGDC 2008).

A complete hierarchical classification is also presented for the zonal component of BEC. The biogeoclimactic zone, subzone, and variant are defined based on mature plant communities of zonal sites and are used extensively in BEC. Higher-level units apply global Köppen bioclimatic types, which rely

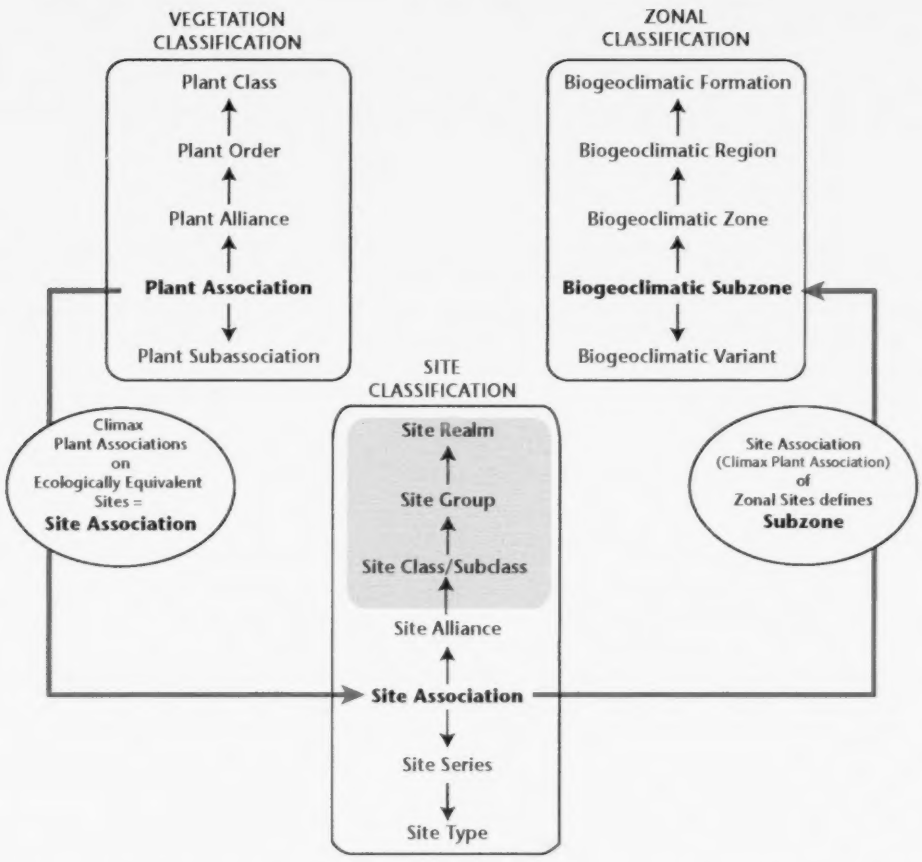



**FIGURE 1** *The Biogeoclimatic Ecosystem Classification framework. New upper-level site units defined in this report are highlighted in grey.*

more broadly on vegetation characters.

In contrast, a hierarchy of BEC site units above a very specific level, the site association, has not been developed. Some proposed intermediate units appear in several publications but remain poorly defined and uncharacterized (Meidinger and Pojar 1991; Klinka and Chourmouzis 2001; Watts and Tolland 2005 ).

Broadly defined site units that use a combination of vegetation potential and underlying environmental factors are applied informally as organizational groups or headings in many publications (e.g., Calder and Taylor 1968; Viereck et al. 1992; Moen 1998). This suggests a need for more generalized units to organize ecological information. Some systems of classification, such as the Canadian Wetland Classification System (NWWG 1988), have defined units consistent with the proposed hierarchy, and are applied here.

This report formalizes four new broader levels for the site component of BEC: site alliance, site class, site group, and site realm. These higher units are created from broadly defined vegetation potential driven by underlying environmental drivers of ecosystems at the site level. In addition, a complete description of site groups and classes is presented for terrestrial non-forested ecosystems. Where possible, existing concepts and terminology are used. Neither site alliances nor broader units of forested ecosystems are presented here.

## 2.2 The Site Association and its Subdivisions

The site association is the fundamental site unit of BEC. All lower levels of the site classification are derived from a division of the site association, and have been previously described (Meidinger and Pojar 1991). Vegetation potential for all lower units is defined using the species composition of the mature-stage plant community.

**Site Association**

The site association defines all sites capable of supporting a similar mature plant association at late succession. A site association is a group of related ecosystems physically and biologically similar enough that they have or would have similar vegetation at the climax stage[1] (Province of British Columbia 2010).

The plant association is a generic unit describing groupings of species recurring across the landscape. These may represent mature, seral, or disclimax plant communities. The site association is specifically the environmental niche of the mature plant association.

**Site Series**

The site series defines all sites capable of supporting the same mature-stage plant association within a single biogeoclimatic (BGC) subzone/variant. The site series has the same name as the site association but is prefixed by the BGC unit in which it occurs and is given a site series number code. Site series of the same site association often occur on sites with different relative site quality (edatopic grid position) between the BGC units where it occurs, reflecting the overarching effect of climate on vegetation.

**Site Type or Site Phase**

The site type or phase defines subdivisions of the site series based on one or more environmental properties (soil or landform) where the plant community does not distinguish environmental differences. When the term site phase is applied, it implies a management-oriented, operational subdivision. The site type is conceptually the lowest level of the site hierarchy and can be used to characterize sites that are uniform in the greatest number of site and soils features. At this time, it is not widely used.

**Site Variation**

The site variation is a subdivision of a the site series or site association used where there is notable variation in the vegetation composition within a site series that does not reflect differences in site condition: a dominant species may not be a good site indicator (very wide ecological amplitude), or the species reflects a non-site factor, such as stochastic establishment events. The term seral variation is used to define early successional–stage plant communities that occur on the site conditions of a defined site series.

## 2.3 Units that Group the Site Association

Above the site alliance, stand-level vegetation potential is described by vegetation structure and common species adaptations rather than by taxonomy.

The creation of broad site units is agglomerative, with the site association as the fundamental unit grouped into Alliances and Classes, Classes joined into Groups, and Groups joined into Realms (Figure 1). The units of each level are guided by different principles and parameters (Table 1). As with the site association, vegetation indicators used in higher-level site unit definitions

1 The use of climax species to name site associations does not imply that mature plant communities dominate the present landscape.

**TABLE 1** *Ecosystem attributes used to differentiate between units of the same biogeoclimatic hierarchical level*

| BEC site unit | Differentiating ecosystem attribute |
|---|---|
| Series | Site association related to a specific biogeoclimatic unit |
| Association | Biological (plant) community reflecting specific site and climate conditions |
| Alliance | Species assemblages with broadly similar environmental requirements |
| Class | Ecosystems with broadly similar site conditions along dominant environmental gradients as reflected in physiognomy (the life form, structure, and stature of vegetation) and species with similar adaptations. Subclasses describe subtypes of the Class based on physiognomic or gradient subdivisions. |
| Group | Ecosystems that can be described by a common dominant environmental gradient(s) |
| Realm | Ecosystems with common water source and character (and primary energy source) |

are based on characteristics of mature vegetation. When classifying seral vegetation, stage of vegetation development should be taken into account, vegetation characteristics should be used with caution, and site and environmental characters should be emphasized.

**Site Alliance**

The site alliance defines groups of site associations with broadly similar soil moisture and nutrient regimes, climatic regimes, and associated climax plant communities. Unlike the site class described below, species composition and regional climate are important defining characteristics of the alliance. The site alliance is related to the plant alliance or suborder of the vegetation component of BEC, but it is more broadly defined based on environmental factors. Diagnostic species groups reflect common climate, hydrology, and moisture/nutrient factors. An example of such a unit could be "rich, saturated boreal sedge fens" defined by basic groundwater, sedges indicative of permanent surface water levels (*Carex limosa, Trichophorum alpinum, T. cespitosum*), and brown mosses. The site alliance may be used for informal groupings of site associations, as no formal alliance units are currently described.

**Site Class/Subclass**

The Class is the fundamental unit of the Canadian Wetland Classification System (NWWG 1988). Wetland classes are broad groupings of wetland ecosystems based on similar environmental factors (primarily hydrology), vegetation physiognomy, and, to a lesser extent, species "guilds." The system is designed for nation-wide application and for non-technical users. Wetland classes are intentionally broad and not defined by species indicators. This unit is the conceptual basis for the site class presented in this report.

The site class describes ecosystems with similar basic underlying environmental attributes that support similar characteristic vegetation physiognomy and species adaptation guilds at climax. Subclasses may be designated for some classes based on physiognomic or environmental subdivisions.

**Site Group**

The site group designates a broad association of functionally similar ecosystems based on a dominant cluster of ecologically relevant environmental features. The site group joins site classes that may have different physiognomy but have common adaptations to a dominant environmental factor(s).

For this reason, each site group requires a different conceptual model of primary environmental drivers to describe ecosystem variability at the site

level. For example, the edatopic grid used for forested ecosystems uses soil moisture and soil nutrient gradients as the primary explanatory variables distinguishing site series. For the alpine group of ecosystems, however, snow cover is the primary determinant of site variability, so the classic edatopic grid is not suitable and must be replaced with an alternate model that uses snow cover regime as one of the primary axes.

**Site Realm**

Figure 2 shows the relationship between broad ecosystem types (Fraser et al. 1995). The original intent was to help delineate areas of responsibility between agencies for ecological classification projects, but it also provides a high-level framework for relating terrestrial ecosystems to other ecosystems.

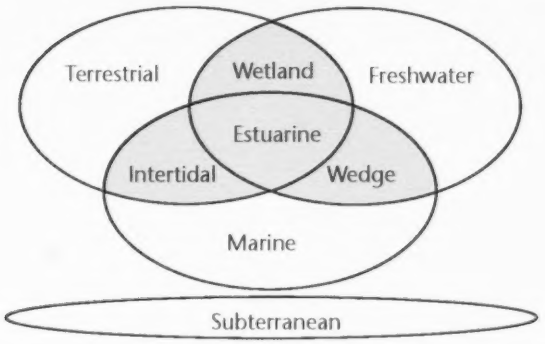



**FIGURE 2** *Diagram of site (ecosystem) realms (modified from Fraser et al. 1995). Core realms are unshaded; interface realms are shaded grey.*

The site realm delineates major biotic types that reflect gross differences in water abundance, quality, and source. Units of the Terrestrial, Wetland, and Estuarine Realms are defined in this paper.

## 3 CRITERIA FOR NON-FORESTED TERRESTRIAL GROUPS AND CLASSES

Site associations grouped into Classes and then Groups must reflect and be described by similar dominant environmental parameters. No strict rules are applied, but clear defining characters must be outlined in supporting models, descriptions, and keys. The site criteria used must be explanatory of the common vegetation physiognomy and species guild.

### 3.1 Physiognomic Cover Criteria

Physiognomy (the life form, structure, and stature of vegetation) is an important defining character in this broad classification system. We use a 10% average cover rule for all definitions (e.g., treed units have >10% average tree cover) (Province of British Columbia 2002).[2]

2 Assignment of individual plots to associations will apply broader rules of cover cut-off. For associations with <10% cut-offs (e.g., grassland versus shrubland), occasional plots with up to 15% cover may be included. For associations with a >10% cut-off (i.e., forested versus non-forested), plots with as little as 7% may be included.

For the purposes of this paper, "forested" is broadly defined to include treed and woodland units:

> *Sites that support only sparse tree cover (< 10%) are non-forested. Sites with > 10% cover of trees > 10 m in height are treated as forested. Sites where maximum height of tree species at climax is < 10 m will be evaluated: forest types with continuous tree cover and normal growth form are generally considered to be "forested" even if stands do not meet the 10 m height criterion (e.g., bog woodlands).*[3]

### 3.2 Coding of Ecosystem Units

Letter codes are assigned to all units presented in this guide. For classes and associations, two-letter codes are used, and combine a higher-level letter codes with a class designation. For classes of the Terrestrial Realm, this code is a combination of the Group and the Class, as in the following examples:

- Fl = Flood Group/Lowbench Class
- At = Alpine Group/Tundra Class

For other realms, the code is a combination of the Realm and the Class:

- Wb = Wetland Realm/Bog Class
- Em = Estuarine Realm/Marsh Class

Site associations within each of these code groupings are given two-digit numerical identifiers. In MacKenzie and Moran (2004), the number series (01–99) was divided between coastal and interior types (01–49 for interior; 50–99 for coastal), but other conventions may be followed for other Groups. Generally, the most common types will be the first ecosystems in a number series, with less common ecosystems numbered later in the series.

There are some treed ecosystems that may receive both a typical BEC site series number and an association code designation. These include treed bogs and swamps, middle benches, forested avalanche ecosystems, and any other ecosystem that belongs to a group or class defined in this report but also meets the criteria for "forested" as defined above.

Examples:

- ICHmc2/06(Fm02) Cottonwood – Dogwood middle benches
- ICHmc2/07(Ws10) Redcedar – Skunk cabbage swamps
- ICHmc2/08(Wb05) Black spruce – Water sedge – Peat-moss bogs

### 3.3 Non-forested Associations that Cross Class or Group Boundaries

The site association is the working unit of the BEC system and is based on the plant association. In some site associations, the plant association does not discriminate among important site conditions that have been used to differentiate at the class level. For forested ecosystems, site series phases are used to describe different site or soil conditions of management interest within an ecosystem unit. We use the central concept principle for non-forested ecosystems, with units coded by the class that represents the typic condition. However, if the association occurs commonly across two (or more) classes, then the association is split into different classes, even though the plant association may be the same. These two classes will occur together in a vegetation hierarchy.

For example, water sedge – beaked sedge communities are a very common plant association that occurs equally on mineral and peat substrates. Because this association is characterized by few species and large ecological amplitude

3 Note that this is a rule-of-thumb only and exceptions may be proposed.

of species, there is no differentiation between marsh and fen condition. In this case, two associations are defined coded as Wfo1 and Wmo1 in *Wetlands of British Columbia* (MacKenzie and Moran 2004).

## 4 SITE REALMS

The site realms define broad functional groupings of ecosystems that share common energy sources and environmental constraints.

### 4.1 Core Realms

There are four core realms that reflect major biomes (unshaded in Figure 2).

**Terrestrial Realm**
Ecosystems of aerobic environments generally powered through photosynthesis and dominated by vascular and non-vascular plant species adapted to varying degrees of drought conditions

**Freshwater Realm**
Inland aquatic ecosystems dominated by organisms adapted to permanent submersion; generally dominated by phytoplankton and stenohaline (salt intolerant) organisms; broadly divided into Lentic and Lotic Groups

**Marine Realm**
Oceanic aquatic ecosystems dominated by organisms adapted to permanent submersion by eusaline waters; generally thermally stable and driven by macro algae, phytoplankton, and other photosynthesizers; broadly divided into pelagic, abyssal, and benthic groups

**Subterranean Realm**
Includes underground ecosystems with limited or no presence of sunlight, including caves and subsoil regions; largely driven by energy sources other than sunlight and dominated by obligate or facultative cave-dwelling animals (trogolobites and troglophiles) or soil invertebrates and fungi

### 4.2 Interface Realms

Interface realms occupy the ecological transition between the core realms and have characteristics of each core realm plus emergent properties (shaded in Figure 2).

**Intertidal Realm**
Ecosystems at the interface between the marine and terrestrial realms affected by tides and alternately submerged and exposed by eusaline waters; dominated by marine algae and invertebrates; defined by vertical stratification, indicating degree and length of tidal inundation

**Wedge Realm**
Ecosystems at the interface between marine and freshwater realms; aquatic area of reduced and variable salinity

**Estuarine Realm**
Ecosystems at the interface between marine, freshwater, and terrestrial realms; intertidal areas influenced by freshwater and dominated by vascular plants tolerant of saturated, saline soils

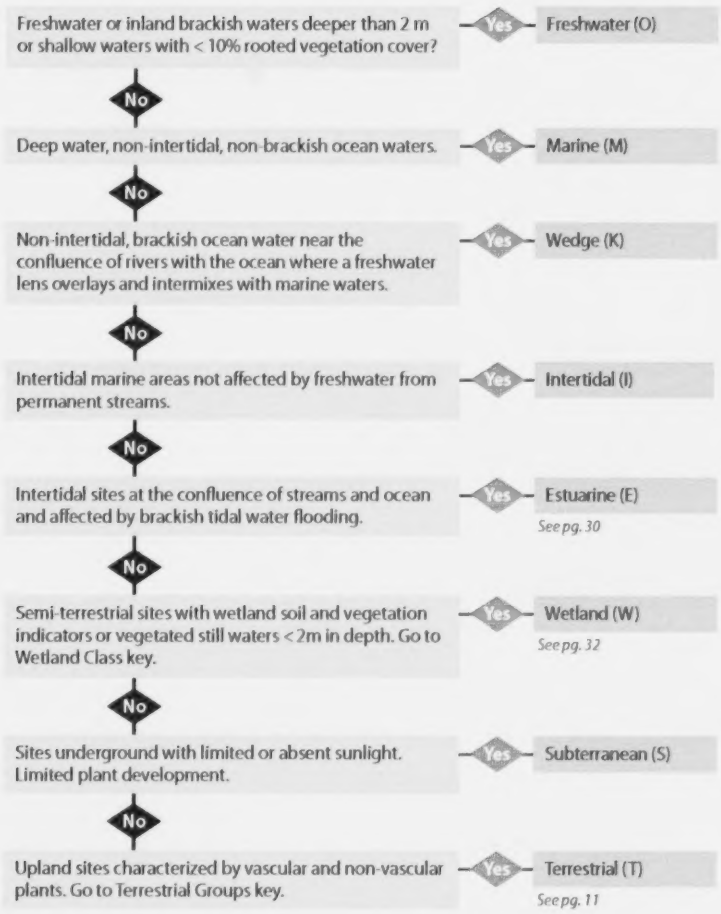

Freshwater or inland brackish waters deeper than 2 m or shallow waters with < 10% rooted vegetation cover?
Yes
Freshwater (O)
No
Deep water, non-intertidal, non-brackish ocean waters.
Yes
Marine (M)
No
Non-intertidal, brackish ocean water near the confluence of rivers with the ocean where a freshwater lens overlays and intermixes with marine waters.
Yes
Wedge (K)
No
Intertidal marine areas not affected by freshwater from permanent streams.
Yes
Intertidal (I)
No
Intertidal sites at the confluence of streams and ocean and affected by brackish tidal water flooding.
Yes
Estuarine (E)
See pg. 30
No
Semi-terrestrial sites with wetland soil and vegetation indicators or vegetated still waters < 2m in depth. Go to Wetland Class key.
Yes
Wetland (W)
See pg. 32
No
Sites underground with limited or absent sunlight. Limited plant development.
Yes
Subterranean (S)
No
Upland sites characterized by vascular and non-vascular plants. Go to Terrestrial Groups key.
Yes
Terrestrial (T)
See pg. 11

**FIGURE 3** *Key to site realms.*

**Wetland Realm**

Ecosystems at the interface between the terrestrial and freshwater realms; dominated by vascular and non-vascular plants adapted to saturated soils and periodically or permanently anaerobic soil conditions

## 5 GROUPS AND CLASSES OF THE TERRESTRIAL REALM

The Terrestrial Realm includes all ecosystems that have relatively well-aerated soils. In most of British Columbia, the "modal" or "typic" ecosystem type on terrestrial sites is conifer forest. However, there can be limiting environmental factors that preclude sites from being conifer forest. The Terrestrial Groups outlined in this paper define groups of associations that share broadly defined environmental limiting factors and corresponding gradients (Table 2). A list of possible reasons for lack of forested condition on terrestrial sites is outlined in Table 2.

**TABLE 2** *Tree-limiting environmental factors and dominant site gradients for groups of the Terrestrial Realm*

| Group | Factors limiting forest establishment | Dominant site gradients |
|---|---|---|
| Alpine | Cold and/or snow | Snow cover and soil moisture regimes |
| Avalanche | Repeated site disturbance by avalanching | Avalanche periodicity and intensity |
| Beachland | Saltwater spray and flooding | Elevation above tide water / degree of salt-water influence |
| Disclimax | Chronic and intense animal disturbance or internal processes that exclude tree establishment | Categorical disturbance type |
| Flood | Prolonged river flooding and erosion | Duration of flooding and soil moisture |
| Grassland | Excessive climatic or site aridity | Soil moisture and soil nutrient regime |
| Hydrogenic | Unusual hydrology | Water characteristics |
| Rock | Lack of soil, unstable soils, or extreme geology | Substrate erodability and aspect/shading |
| Subalpine Shrub | Cold and/or snow | Soil moisture and snow cover regime |

A key to groups based on these limiting factors is presented in Figure 2.

The keys in Figures 1 and 2 assign a priority for class designation for sites or associations that meet the definition for more than one group or class. The following examples illustrate the implications of this prioritization from the keys:

- Rocky talus cones affected by avalanching are identified as Rock Talus Class; there is no Avalanche Talus Class.
- Rocky alpine areas are identified as Alpine Fellfield Class rather than a class of the Rock Group.
- Rocky areas in grasslands will be identified as Rock Group rather than Grassland.
- Forested wetlands are identified as Wetland Realm rather than Forest Group.
- Zooclimax ecosystems in alpine environments are a separate Alpine Zoogenic Class.
- Meadows or heath in the start zone of avalanche tracks (above treeline) are defined as alpine classes rather than avalanche ecosystems.
- Talus and cliffs affected by waterfall spray are part of the Hydrogenic Group, not the Rock Group.

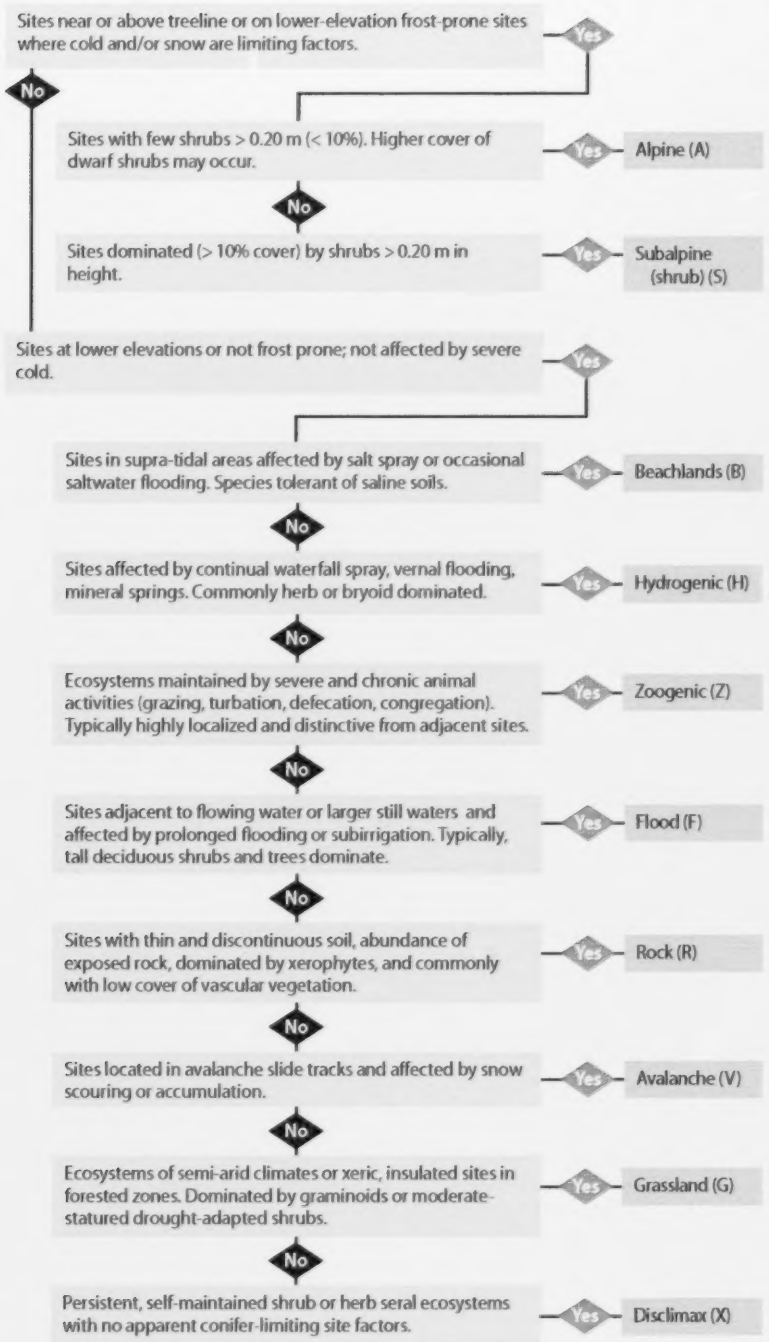

Sites near or above treeline or on lower-elevation frost-prone sites where cold and/or snow are limiting factors.
Yes
No
Sites with few shrubs > 0.20 m (< 10%). Higher cover of dwarf shrubs may occur.
Yes
Alpine (A)
No
Sites dominated (> 10% cover) by shrubs > 0.20 m in height.
Yes
Subalpine (shrub) (S)
Sites at lower elevations or not frost prone; not affected by severe cold.
Yes
Sites in supra-tidal areas affected by salt spray or occasional saltwater flooding. Species tolerant of saline soils.
Yes
Beachlands (B)
No
Sites affected by continual waterfall spray, vernal flooding, mineral springs. Commonly herb or bryoid dominated.
Yes
Hydrogenic (H)
No
Ecosystems maintained by severe and chronic animal activities (grazing, turbation, defecation, congregation). Typically highly localized and distinctive from adjacent sites.
Yes
Zoogenic (Z)
No
Sites adjacent to flowing water or larger still waters and affected by prolonged flooding or subirrigation. Typically, tall deciduous shrubs and trees dominate.
Yes
Flood (F)
No
Sites with thin and discontinuous soil, abundance of exposed rock, dominated by xerophytes, and commonly with low cover of vascular vegetation.
Yes
Rock (R)
No
Sites located in avalanche slide tracks and affected by snow scouring or accumulation.
Yes
Avalanche (V)
No
Ecosystems of semi-arid climates or xeric, insulated sites in forested zones. Dominated by graminoids or moderate-statured drought-adapted shrubs.
Yes
Grassland (G)
No
Persistent, self-maintained shrub or herb seral ecosystems with no apparent conifer-limiting site factors.
Yes
Disclimax (X)

**FIGURE 4** *Key to terrestrial groups.*

While groups are defined primarily by environmental limiting factors and dominant differentiating gradients, each group also reflects broad biological potential and corresponding species groups.

## 5.1 Alpine Group (A)

The Alpine Group includes all ecosystems where cold, short growing seasons and harsh winters, in combination, are too extreme for the establishment and growth of trees or erect shrubs. The limited growing season can be the result of cold air or soil temperatures, high incidence of frost during the growing season, extreme winter conditions, or prolonged snow lay into the growing season. The modal condition for the group is the alpine zone above treeline where the alpine group of ecosystems constitute the entire vegetation. However, alpine group ecosystems occur at lower elevations in azonal locations as well. Alpine-like site conditions and corresponding alpine group ecosystems are generally very common in the subalpine parkland, and become less frequent at lower elevations. Widespread occurrence of alpine group ecosystems at lower (montane) elevations is seen in some regions where sites affected by cold air during the growing season are common, such as the Chilcotin Plateau and the Boreal Mountains ecoregions.

Because the Alpine Group describes an entire biome based on climatic limitations, it requires more classes to describe site variation than other groups presented in this report. Photographs of some ecosystems representing each alpine class are presented in Figure 6.

Snow cover is the primary environmental gradient affecting alpine ecosystems, considering both winter snow cover (protection from winter weather and soil freezing) and growing-season cover (reduction in the effective growing degree days). Soil moisture regime is an important secondary gradient.

There are seven alpine classes in the Alpine Group (Figure 5).

**Alpine Fellfield Class (Af)**

Fellfields are ecosystems of exposed locations where the dynamics of frost (freeze and thaw cycles) and of wind give rise to characteristic low plant cover in a rocky or mineral soil matrix. Thin snowpack leads to active freeze–thaw cycles that act to push plants out of the soil. High porosity or lack of soil makes a fellfield a difficult place for plants to grow. Fellfields are commonly populated by cushion plants (tufted perennials that grow close to the ground) and cryptogams. Subclasses describing Rock (bedrock), Fellfield (typic), Felsenmeer (block field dominated by cryptograms), and Scree (mobile substrates) can be recognized.

**Alpine Grassland Class (Ag )**

Alpine grasslands are well-vegetated, grass-dominated ecosystems of dry, cold climates with low snow load and well-developed soils. Northern alpine Altai fescue grasslands represent typic ecosystems in British Columbia, but alpine grassland ecosystems also occur in southern alpine areas and in lower-elevation cold air–affected sites in the boreal region and Chilcotin plateau. Alpine grasslands differ from the physiognomically similar Grassland Group in that cold winters and growing-season frosts are the driving forces rather than heat and associated growing-season aridity.

**Alpine Heath Class (Ah)**

Alpine heath ecosystems are mountain-heather–dominated snowbeds that are widespread and common throughout British Columbia in snow-accumulating sites and stable substrates. Moderate snow accumulations are of intermediate depth between tundra and nivation ecosystems. Mountain-heather species are always prominent. Site conditions are typically mesic and drier.

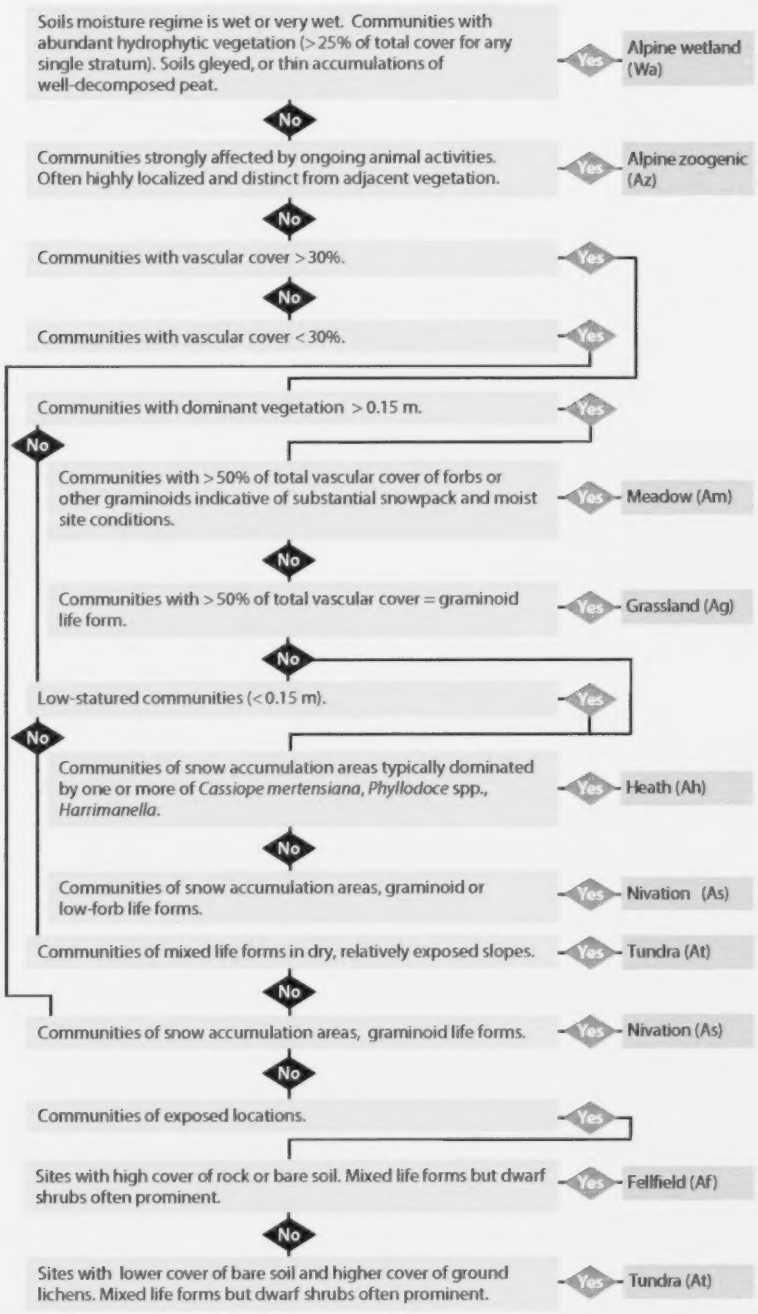

Soils moisture regime is wet or very wet. Communities with abundant hydrophytic vegetation (>25% of total cover for any single stratum). Soils gleyed, or thin accumulations of well-decomposed peat.
Yes
Alpine wetland (Wa)
No
Communities strongly affected by ongoing animal activities. Often highly localized and distinct from adjacent vegetation.
Yes
Alpine zoogenic (Az)
No
Communities with vascular cover >30%.
Yes
No
Communities with vascular cover <30%.
Yes
Communities with dominant vegetation >0.15 m.
Yes
No
Communities with >50% of total vascular cover of forbs or other graminoids indicative of substantial snowpack and moist site conditions.
Yes
Meadow (Am)
No
Communities with >50% of total vascular cover = graminoid life form.
Yes
Grassland (Ag)
No
Low-statured communities (<0.15 m).
Yes
No
Communities of snow accumulation areas typically dominated by one or more of *Cassiope mertensiana*, *Phyllodoce* spp., *Harrimanella*.
Yes
Heath (Ah)
No
Communities of snow accumulation areas, graminoid or low-forb life forms.
Yes
Nivation (As)
Communities of mixed life forms in dry, relatively exposed slopes.
Yes
Tundra (At)
No
Communities of snow accumulation areas, graminoid life forms.
Yes
Nivation (As)
No
Communities of exposed locations.
Yes
Sites with high cover of rock or bare soil. Mixed life forms but dwarf shrubs often prominent.
Yes
Fellfield (Af)
No
Sites with lower cover of bare soil and higher cover of ground lichens. Mixed life forms but dwarf shrubs often prominent.
Yes
Tundra (At)

**FIGURE 5** *Key to alpine classes*

### Alpine Meadow Class (Am)

Alpine meadow ecosystems are forb-dominated (or large sedge–dominated) ecosystems of subalpine and alpine elevations. Vegetation typically has high cover and stature. These ecosystems occur on fresh to moist usually well-developed soils that have continuous winter snowpack. Sites with seepage or unstable soils favour the Alpine Meadow Class over alpine heath ecosystems.

6a

6b

6c

6d

6e

6f

**FIGURE 6** *Alpine Group (A).*

*6a (Ah) Mountain-heather (*Cassiope *and* Phyllodoce *spp.) heath is widespread in snowy environments.*

*6b (At) Mountain-avens (*Dryas integrifolia *and* D. Octopetala*) tundra occurs extensively in very dry climates and favours base-rich soils.*

*6c (Am) Alpine meadows occur commonly near treeline on moist sites with good snow cover.*

*6d (Af) Northern fellfield on rocky peak.*

*6e (As) Piper's wood-rush (*Luzula piperi*) ecosystem emerging from snowbed.*

*6f (Ag) Altai Fescue (*Festuca altaica*) grasslands are characteristic of northern alpine areas but also occur in lower-elevation areas experiencing cold-air ponding.*

*6g (Am) Some alpine meadows are dominated by large sedges, such as large-awned sedge (*Carex macrochaeta*).*

*6h (Af) Active scree slopes often have sparse vegetation of specialized species that are tolerant of mobile substrates.*

*6i (Ag) Treeline fescue grasslands may result in part from warm winter winds, which cause dessication damage to woody plants and forbs (Flathead, southern Canadian Rockies).*

6g

6h

6i

**FIGURE 6** *Alpine Group (A) continued.*

**Alpine Nivation (Late Snowbed) Class (As)**
Alpine nivation ecosystems occur under very deep or persistent snowpacks that last well into the growing season and are commonly of low cover and low species diversity. Few species can tolerate the short growing season and environmental conditions. Erosion during snowbed melting (nivation) and growing-season cryoturbation is extreme due to lack of vegetation cover and high soil moisture.

**Alpine Tundra Class (At)**
Alpine tundra ecosystems are relatively well-vegetated ecosystems of mixed life-form composition, commonly with an abundance of dwarf shrubs. They occur on cold, circum-mesic sites that have moderate snow cover.

**Zoogenic Alpine Class (Az)**
Zoogenic alpine ecosystems are highly localized habitats where animal activities are concentrated. Zoogenic ecosystems may result from rodent digging (plus turbation, grazing, defecation) or ungulate grazing or bedding (plus trampling, defecation). Animal activities affect all ecosystems, but the zoogenic class designation is restricted to those ecosystems where the vegetation is distinctively unrelated to site conditions because of animal use.

## 5.2 Beachland Group (B)

The Beachland Group includes non-forested, seashore zone, supra-tidal ecosystems of beaches and rocky headlands that are affected by salt spray and possible brief saltwater flooding. The entire vegetation is composed of species that are tolerant of salinity. Within each class, the degree of saltwater effect is the primary environmental gradient along which ecosystems differentiate at the site level. Photographs of some ecosystems representing each beachland class are presented in Figure 7.

**Beachland Class (Bb)**
Beachland ecosystems occur on unconsolidated beach sediments (sands/gravels/shells/cobbles) in the supra-tidal zone of the marine environment. These areas are affected by salt spray, wind, and/or water erosion and deposition of marine sediments. Halophytes and graminoid species adapted to continual burying by shifting sands are common in the beach and foredune zones. Ecosystems of stablized dune deposits are included in this class and may have higher cover of shrubs and mosses. This class includes lower beach, upper beach, and dune subclasses (Page et al. 2011).

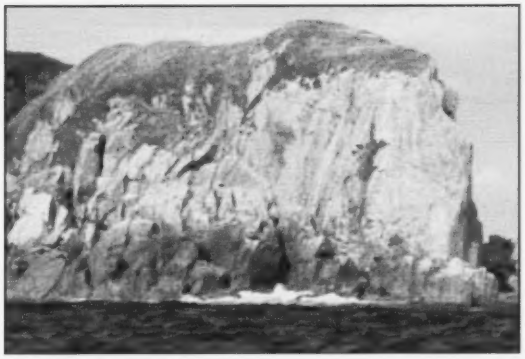
**Headland Class (Br)**
Headland ecosystems occur on rocky islets, headlands, sea cliffs and consolidated parent materials of non-marine origin that are affected by saltwater spray and splashing. The vegetation is floristically diverse and often zoned by elevation above sea level and exposure to sea spray. The lowest zone is a lichen band (Brodo and Sloan 2004); the highest zone may be occupied by salt-tolerant vascular forbs and low shrubs.

*7a* *7b*

**FIGURE 7** *Beachland Group (B).*

7c

7d



7e

7f

7g

**FIGURE 7** *Beachland Group (B) continued.*

*7a (Bb) Beach ecosystem of large-headed sedge (*Carex macrocephala*) and dune tansey (*Tanacetum bipinnatum*) in the upper beach zone (north Graham Island, Haida Gwaii).*

*7b (Bb) Upper beach community of silver burweed (*Ambrosia chammisonis*) and seabeach sandwort (*Honkenya peploides*) on sands and gravels.*

*7c (Bb) Dune wildrye (*Leymus mollis*) ecosystems are widespread and common in upper beach and dune zones.*

*7d (Bb) Stabilized sand flats with continuous cover of coastal strawberry (*Fragaria chiloensis*) (Rose Spit, Haida Gwaii).*

*7e (Br) Rocky headland ecosystems are common in exposed coastal locations.*

*7f (Bh) Rocky headland on small islet in protected waters.*

*7g (B) Sparsely vegetated sea-rocket (*Cakile edentula*) ecosystem in the lower beach zone.*

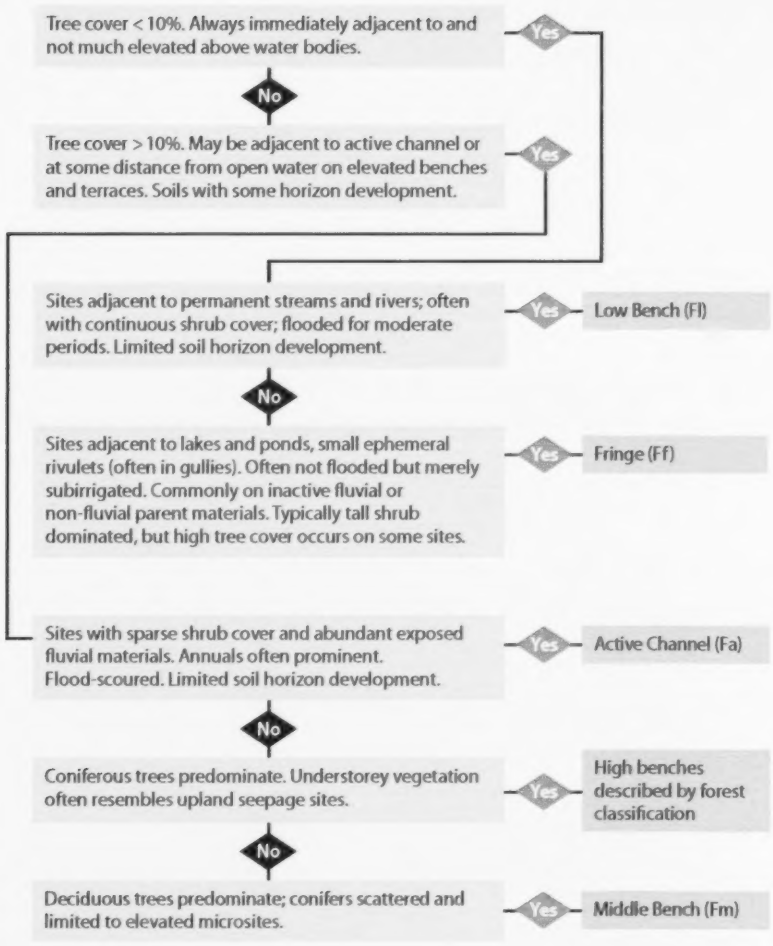

Tree cover < 10%. Always immediately adjacent to and not much elevated above water bodies.
Yes
No
Tree cover > 10%. May be adjacent to active channel or at some distance from open water on elevated benches and terraces. Soils with some horizon development.
Yes
Sites adjacent to permanent streams and rivers; often with continuous shrub cover; flooded for moderate periods. Limited soil horizon development.
Yes
Low Bench (Fl)
No
Sites adjacent to lakes and ponds, small ephemeral rivulets (often in gullies). Often not flooded but merely subirrigated. Commonly on inactive fluvial or non-fluvial parent materials. Typically tall shrub dominated, but high tree cover occurs on some sites.
Yes
Fringe (Ff)
Sites with sparse shrub cover and abundant exposed fluvial materials. Annuals often prominent. Flood-scoured. Limited soil horizon development.
Yes
Active Channel (Fa)
No
Coniferous trees predominate. Understorey vegetation often resembles upland seepage sites.
Yes
High benches described by forest classification
No
Deciduous trees predominate; conifers scattered and limited to elevated microsites.
Yes
Middle Bench (Fm)

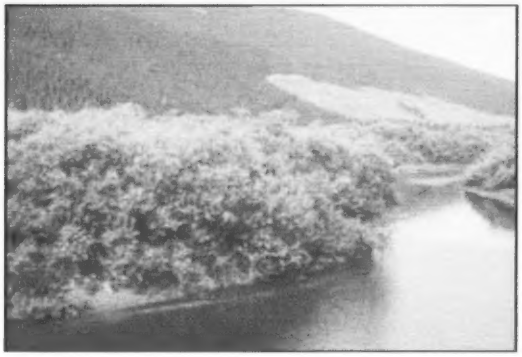
**FIGURE 8** *Key to flood classes.*

## 5.3 Flood Group (F)

The Flood Group includes ecosystems that are regularly flooded by river or lake waters for sufficient duration to preclude establishment of conifer forest. Included in this class are tall deciduous tree and shrub ecosystems that occur on non-alluvial soils around lakes and along ephemeral creek gullies, primarily in dry climates (Fringe Flood Class). The duration of flooding is the primary environmental gradient differentiating flood ecosystems at the site level, but growing-season soil moisture is an important secondary factor. Photographs of some ecosystems representing each flood class are presented in Figure 9.

**Active Channel Flood Class (Fa)**

Active channel ecosystems occur on sites that are annually flooded, and often scoured, for prolonged periods. Sites are usually immediately adjacent to the river channel at lower water conditions. On unstable substrates, such as gravel bars and islands, ecosystems are usually dominated by annuals or herb-layer species with extensive root systems that enable resprouting when the above-ground structures have been removed. Bryoid communities are more typical on active channel sites with more stable substrates.



9a

9b

9c

9d

9e

9f

**FIGURE 9** *Flood Group (F).*

*9a (Fl) Drummond's willow (*Salix drummondiana*) – Bluejoint (*Calamagrostis canadensis*) ecosystems occur on levees adjacent to low-gradient streams.*

*9b (Fm) Cottonwood (*Populus balsamifera*) ecosystems are found on active floodplains of small to large rivers at low elevations.*

*9c (Ff) Drainage gullies in dry climates may support fringe flood ecosystems.*

*9d (Fm) Wave-washed shores of larger lakes may support middle bench ecosystems (Chilco Lake).*

*9e (Fa) Streamside moss (*Scouleria aquatica*) active channel ecosystems on bedrock along the Bulkley River.*

*9f (Fa) Streamside moss (*Scouleria aquatica*) active channel ecosystems along the Bulkley River.*

**Low Bench Flood Class (Fl)**
Low bench ecosystems occur on sites that are flooded for moderate periods (< 40 days) of the growing season—conditions that limit the canopy to tall shrubs, especially willows or alders. Annual erosion and deposition of sediments (sands and silts) generally limit understorey and humus development. These ecosystems are most commonly associated with fluvial systems but also occur on wave-washed beaches of larger lakes. They are floristically related to many shrub swamps but occur on non-wetland soils and do not have an abundance of hydrophytes.

**Middle Bench Flood Class (Fm)**
Middle bench ecosystems occur on sites briefly flooded (10–25 days) during freshet, allowing tree growth, but forests are dominated by flood-tolerant broadleaf species, such as black cottonwood and red alder. Conifers may occur on elevated microsites but are less abundant than deciduous trees.

**Fringe Flood Class (Ff)**
Fringe flood ecosystems develop on subirrigated but rarely flooded non-alluvial soils next to lakes and other still waters, or in slope draws and gullies in areas with dry climates. High soil moisture and modified climates produce tall broadleaf shrub or low treed ecosystems that are distinct from the adjacent upland. These ecosystems are differentiated from the Brushland Class in dry environments by tall shrub physiognomy and moist site conditions.

## 5.4 Grassland Group (G)

The Grassland Group describes sites that are too dry for tree establishment as a result of semi-arid macroclimate or very dry and warm sites within forested zones. A grass-dominated community type is the modal condition, but other graminoids or shrubs may dominate. Even for these communities, however, the semi-arid climate, often coupled with well-drained soils, is the factor that limits tree establishment. This group constrasts with the Alpine Grassland Class where cold is the site limiting factor. Ecosystem variation at the site level responds largely to soil moisture, but moisture seasonality, depth, and drainage characteristics are also important.

Within this Group, there are four classes. Photographs of representative grassland ecosystems are presented in Figure 11.

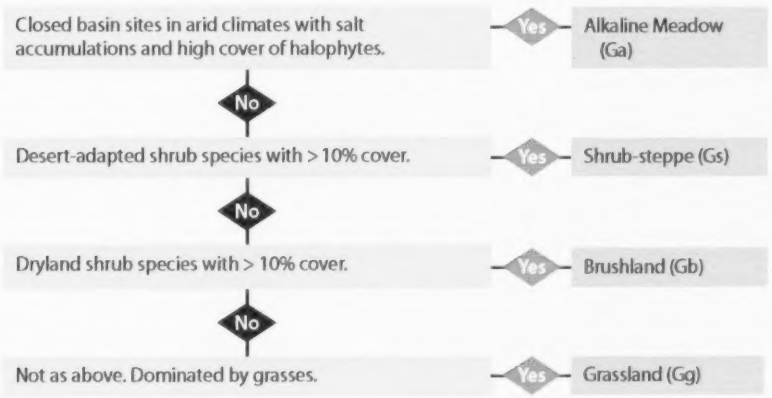
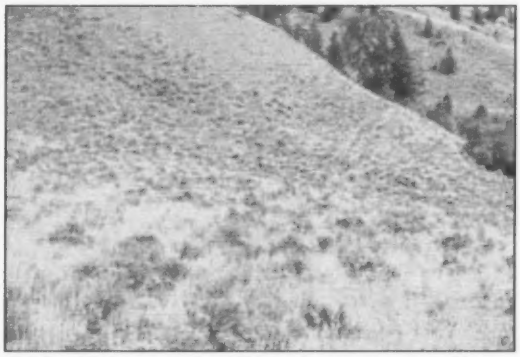



**FIGURE 10** *Key to grassland classes.*

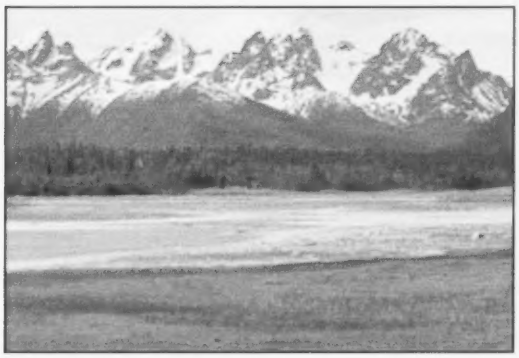
*11a*

*11b*

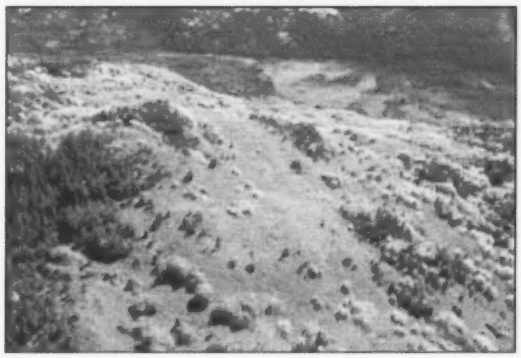
*11c*



*11d*



*11e*



*11f*

**FIGURE 11** *Grassland Group (G).*

*11a (Gg) Grasslands dominate the landscape in areas of semi-arid macroclimate (Bunchgrass zone, confluence of Fraser and Chilcotin Rivers).*

*11b (Gg) In most regions of British Columbia, grasslands are localized on dry, warm aspect slopes (Boreal White and Black Spruce zone, Cassiar Mountains).*

*11c (Gb) Brushland ecosystems often occur on sites with thinner, rocky soils than grasslands (Gg).*

*11d (Gs) Shrub-steppe ecosystems occur in British Columbia only in the warmest and driest interior climates, which represent the northern extent of the Great Basin biome.*

*11e (Ga) Alkali meadows occur in dry climates. Annual evaporation of water in closed basins leads to accumulation of salts.*

*11f (Gg) In forested regions, grasslands are generally limited to dry, insolated slopes (Ootsa reservoir).*

**Grassland Class (Gg)**
The Grassland Class defines typic grassland ecosystems that are widespread in semi-arid climates and on very dry sites in non-grassland climates. These ecosystems are graminoid-dominated associations that occur primarily on deep soils, but sites are dry because of very rapid soil drainage, insolation, and/or lack of precipitation. If shrubs occur, they are sparse (< 10%) or of lower stature than grasses. On thinner soils, these communities border on members of the Rock/Talus Group. Site conditions that are similar but are dominated by shrubs are part of the Shrub-steppe or Brushland Classes.

**Shrub-Steppe Class (Gs)**
Shrub-steppe ecosystems occur only in the relatively hot, semi-arid climates of British Columbia (Bunchgrass / Ponderosa Pine and very dry and hot Interior Douglas-fir biogeoclimatic areas), and are dominated (> 10%) by semi-desert–adapted, drought- and heat-tolerant, woody shrubs of medium stature but greater stature than the herb layer. Shrub-steppe species such as sagebrush (*Artemisia tridentata*), or antelope-brush (*Purshia tridentata*) are prominent.

**Brushland Class (Gb)**
Brushland ecosystems occur outside of warm semi-arid climates and are dominated (> 10%) by drought-tolerant woody shrubs of moderate stature. Temperate species such as saskatoon (*Amelanchier alnifolia*), junipers (*Juniperus* spp.), cherries (*Prunus* spp.), and snowberry (*Symphoricarpus* spp.) are typical.

**Alkaline/Saline Meadow Class (Ga)**
Alkaline/saline meadows are graminoid- or halophyte-dominated sites that occur in shallow, closed basins of dry inland climates where evaporation of standing waters leads to the progressive accumulation of salts. These conditions occur only in the driest climates of British Columbia. Interannual variation in hydrology is typical for these closed basin systems. But generally, after a brief period of inundation, a surface water table drops below the rooting zone for the growing season, resulting in a well-aerated rooting medium. This class was previously described and coded as Saline meadow Transition Class (Gs) in MacKenzie and Moran (2004). A halophyte subclass dominated by succulent species such as *Suaeda* spp. or *Salicornia* spp. is recognized.

## 5.5 Hydrogenic Group (H)

The Hydrogenic Group includes a disparate suite of ecosystems that are affected by specialized water conditions not covered by other groups. These ecosystems are commonly highly localized and support uncommon species that are specifically adapted to the unusual environmental conditions. Environmental gradient differentiating ecosystems at the site level are largely related to hydrological characteristics and gradients that are specific to the class. Photos of some ecosystems representing each hydrogenic class are presented in Figure 12.

**Spring-seepage Class (Hs)**
Spring-seepage ecosystems occur on mineral springs and seeps but do not meet the criteria for wetland ecosystems. Spring-seepage ecosystems often have very distinctive vegetation that is tolerate of the mineral accumulations and specific mineralogy of the seepage. These ecosystems include tufa, traverntine, and hydromagnesite springs and associated deposits. Spring-

12a

12b

12c

12d

**FIGURE 12** *Hydrogenic Group (H).*

*12a (Hh) Mineral springs support unusual vegetation, such as this ecosystem dominated by evergreen saxifrage (*Saxifraga aizoides*) (Likely–Barkerville road, Quesnel Highlands).*

*12b (Hw) Zones of continuous water spray around larger waterfalls create unique site conditions for vegetation (Horsefly River falls).*

*12c/12d (Hv) Vernal pool on coastal rock outcrop in flooded winter (c) and moist spring (d) condition. This site supports one of four populations in the world of the globally endangered plant,* Castilleja victoriae *(Victoria)*
*Photos: Matt Fairbarns.*

seepage ecosystems are more common in areas of base-rich geology, such as the Rocky Mountain Trench.

**Vernal Pool Class (Hv)**

Vernal pool ecosystems occur in shallow, often bedrock-controlled, closed basins that contain water in the winter and early spring but dry by early growing season. Commonly these ecosystems are small and have distinctive vegetation of annuals and perennial herbs that are adapted to grow during the autumn or early spring when soils are saturated (Parks Canada Agency 2006). These ecosystems occur in British Columbia only in the Mediterranean climates of the south coast and Vancouver Island (Coastal Douglas-fir [CDF] zone and very dry Coastal Western Hemlock [CWHxm] subzone).

**Waterfall Spray Class (Hw)**

Waterfall spray ecosystems occur adjacent to larger waterfalls where a localized zone of continuous water spray restricts tree establishment and affects vegetation. Vegetation is commonly herb or bryoid dominated. Specialized species may occur.

## 5.6 Rock Group (R)

The Rock Group includes lowland sites with little soil, abundant cover of rock or bedrock, and generally low cover of vascular plants. Ecosystem variation at the site level is influenced by rock characteristics and small variances in site moisture (from microclimatic differences or patterns of periodic sheet flow) (Sadler 2007). This group does not include Alpine Fellfield or supra-tidal Headland Class. Photographs of some ecosystems representing each rock class are presented in Figure 13.

**Cliff Class (Rc)**
Cliff ecosystems are vertical rock sites, commonly with high bryophyte cover (rock crusts), but small pockets of soils may support vascular vegetation.

**Rock Outcrop Class (Ro)**
Rock outcrop ecosystems are bluffs and knobs of bedrock with limited soil development and high cover of exposed rock. Drought-tolerant cryptogams are often prominent and vascular plants are limited. Subclasses based on geologic characteristics can be differentiated (e.g., ultramafic/serpentine; limestone subclasses).

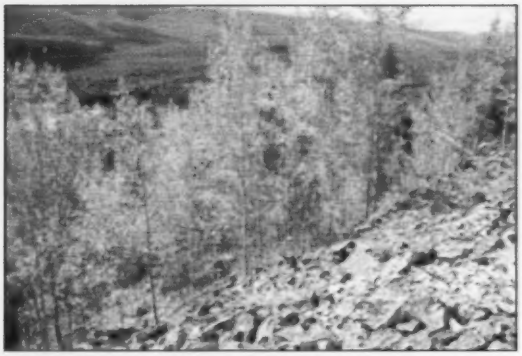
**Talus Class (Rt)**
Talus ecosystems are active and inactive talus (large rocks) and scree (smaller rocks and more soil). These ecosystems typically have a low herb layer cover because of mobile substrates or lack of soil. Stable talus may have high bryophyte cover, particularly on cool aspects with stable substrates, or vegetation similar to adjacent rock outcrop communities. Some stable talus ecosystems may have some cover of deciduous trees or shrubs. Unstable sites may have distinct communities of species that are tolerant of mobile substrates. Talus (stable) and Scree (unstable) subclasses can be described.

**Lava Flow Class (Rl)**
Lava flow ecosystems occur on basalt flows of pahoehoe pavement and broken aa lava forms. Vegetation structure and composition depends on the degree of soil accumulation and moisture, but there is generally a high cover of cryptogams and bryophytes. Other volcanic landforms such as columnar basalt towers and talus are described by the Rock Outcrop and Talus Classes. Subclasses based on flow type (pahoehoe or aa) can be differentiated.

**Dune Class (Rd)**
Dune ecosystems are active inland aeolian deposits that remain sparsely vegetated due to high substrate mobility. Species that are tolerant of mobile substrates and abrasion are typical. The ecosystems are not strictly rock ecosystems but have species affinities with this group and so are placed here. Coastal dunes are part of the Beachland Group.

13a

13b



13c

13d

13e

13f

**FIGURE 13** *Rock Group (R).*

*13a (Ro) Rock outcrops are commonly a mosaic of community types at a small scale based on variable aspect/shading or soil depth.*

*13b (Ro) A small rock outcrop infested with introduced grasses in the Gulf Islands.*

*13c (Rt) Blocky talus with little herb- or moss-layer vegetation but moderate cover of trembling aspen.*

*13d (Rc) Cliff habitat on mesa edge, Fort Nelson.*

*13e (Rl) Lava flows can remain largely bryoid dominated for centuries since formation (Tseax lava beds, New Aiyansh).*

*13f (Rd) Inland sand dunes often have unique but sparse vegetation.*

## 5.7 Subalpine Shrub Group (S)

The Subalpine Shrub Group includes ecosystems with cold winters and short growing seasons, which limits the establishment and growth of trees but is suitable for supporting moderate-stature shrubs (0.2–10 m). As with forested ecosystems, soil moisture is the primary environmental gradient differentiating subalpine shrub ecosystems at the site level. Photographs of some ecosystems representing each subalpine class are presented in Figure 14.

**Shrubland Class (Sc)**

A shrubland is a low deciduous, shrub-dominated ecosystem that develops on frost-prone sites with dry to very moist soils. Subalpine shrublands are widespread at the treeline in cold, dry climates but they also occur in frost-prone hollows at lower elevations. In snowier climates, shrub-carrs are often limited to weak seepage gullies that have winter snow cover and warmer soil temperatures due to seepage. Two subclasses can be recognized: shrub-carrs occur on sites with moist and very moist site conditions, and shrubland occurs on drier sites.

**Krummholz Class (Sk)**

Krummholz are conifer shrub–dominated ecosystems that occur at the treeline, the upper elevations of conifer tolerance. Conifers are commonly of dwarfed stature due to harsh environmental conditions, including low growing-season temperatures and winter frost and wind damage. Site conditions are typically well- to rapidly drained with thin or coarse-textured soils. Some types are floristically similar to lower-elevation subalpine forests.

*14a*

*14b*

**FIGURE 14** *Subalpine Shrub Group (S).*

14c

14d

14e

**FIGURE 14** *Subalpine Shrub Group (S) continued.*

*14a (Sc) Black huckleberry (*Vaccinium membranaceum*) shrubland occurs at the treeline in very snowy climates, Hannah Range, Meziadin.*

*14b (Sk) Whitebark pine (*Pinus albicaulis*) and subalpine fir (*Abies lasiocarpa*) krummholz on rubbly insulated slope, Akamina-Kishinena.*

*14c (Sc) More localized areas of shrubland are often found in matrix with alpine meadow near the treeline, Sicintine Range.*

*14d (Sk) Upper-elevation krummholz grades into tundra, Itcha Mountain.*

*14e (Sc) Extensive scrub birch (*Betula nana*) shrubland is common at the treeline in northern British Columbia, Chilkat Pass, Haines Highway.*

## 5.8 Avalanche Group (V)

The Avalanche Group includes ecosystems maintained by regular snow avalanches. These occur in mountainous terrain and are more common in snowier environments. Most avalanche start zones occur in alpine or subalpine elevations; these are commonly described by alpine classes with the track and run-out zones described by classes of the Avalanche Group. The degree of avalanche influence (frequency, power, and snow deposition) and soil moisture regime are the two most important environmental gradients affecting avalanche ecosystems at the site level. Photographs of some ecosystems representing each avalanche class are presented in Figure 15.

**Avalanche Herb Meadow Class (Vh)**

Avalanche herb meadows are ecosystems in avalanche tracks that are dominated by forbs, graminoids, and/or dwarf woody shrubs. These ecosystems often occur in the central track or run-out zone of avalanche paths where snow accumulates or where mobile substrates limit the establishment of shrubs or trees. Rocky talus cones affected by avalanches are placed in the Talus Class.

*15a*

*15b*

*15c*

*15d*

**FIGURE 15** *Avalanche Group (V).*

*15a (Vs) Sitka alder (*Alnus viridus *ssp.* sinuata*) is common and dominant in many avalanche tracks in the snowy regions of British Columbia.*

*15b Dry Vh avalanche herb meadow ecosystem (Vh) adjacent to treed avalanche (Vt) ecosystem in the runout zone.*

*15c (Vh) Forb-rich avalanche ecosystems are common where snow accumulates and sites are well watered in lower areas of avalanche tracks.*

*15d (Vt) Treed avalanche ecosystems commonly occur where avalanche paths are unconstrained.*

**Avalanche Shrub Thicket Class (Vs)**
Avalanche shrub thickets are ecosystems in avalanche tracks that are dominated by deciduous shrubs and are most frequently associated with the track and lateral run-out portions of the avalanche path where deep snow lay occurs infrequently but site conditions are fresh or wetter.

**Avalanche Treed Class (Vt)**
Avalanche treed ecosystems are dominated by shrub-sized trees that are continually pruned by snow slides and are prevented from becoming forest. This does not include young forests that are regenerating from single extreme events; such forests are seral ecosystems. Trees in Vt ecosystems show evidence of pruning and bark damage from chronic avalanche events. Site conditions are typically dry.

## 5.9 Disclimax Group (X)

The Disclimax Group describes ecosystems that are maintained by non-environmental factors. Photographs of some ecosystems representing disclimax classes are presented in Figure 16.

**Vegetation (Autogenic) Disclimax (Xv)**
The vegetation disclimax class describes ecosystems where vegetation competition rather than environmental constraints maintains the non-forested state. Vegetation is generally lush enough to preclude tree establishment through shading, litter fall, or some other resource factor. These ecosystems may have floristic similarities to other classes of ecosystem but lack apparent environmental drivers. Subclasses for herb-dominated and shrub-dominated ecosystems can be differentiated.

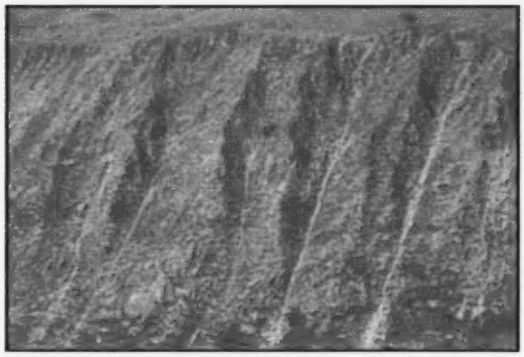
**Zoogenic Disclimax (Xz)**
This class includes ecosystems where intense and ongoing animal activity leads to ecosystems that contrast markedly from the adjacent ecosystem matrix in structure and/or species composition. These areas are typically of restricted geographic extent.

Subclasses can be differentiated by the type of animal activity: grazing zooclimax ecosystems experience intense seasonal use by herd animals; nesting zooclimax ecosystems experience intense seasonal use by communal nesters (primarily birds); turbation zooclimax ecosystems are created by burrowing fossorial animals. Zooclimax ecosystems in alpine environments are described by an Alpine Zoogenic (Az) class.

**Anthropogenic Disclimax (Xa)**
This class includes ecosystems where intense and ongoing human or domestic animal activity leads to ecosystems that contrast markedly from the adjacent ecosystem matrix in structure and/or species composition. These ecosystems are generally not common because the term "anthropogenic" is reserved for ecosystems that are specifically adapted to persistent and consistent management practices, such as multi-generational old-world field management.

16a

16b



16c

**FIGURE 16** *Disclimax Group (X).*

*16a (Xz) Distinctive vegetation community of Jacob's ladder (*Polemonium *sp.) and stonecrop (*Sedum *sp.) on a Herring Gull nesting site, Atlin Lake.*

*16b (Xv) Differentiating vegetation disclimax ecosystems from seral ecosystems may present challenges. This low-elevation meadow dominated by bracken fern (*Pteridium aquilinum*), cow-parsnip (*Heracleum maximum*), and Indian riceroot (*Fritillaria camschatcensis*) occurs in predictable locations and has very distinct soils, suggesting longevity. However, no clear rationale for its occurrence in the landscape is established.*

*16c (Xz) Stone's sheep winter habitat occurs on steep, south-facing slopes near the treeline in northern British Columbia. Plant communities of arctic sedge (*Carex supina*) and purple reedgrass (*Calamagrostis purpurascens*) are associated with these sites. Zoogenic disclimax designation of ecosystems such as these is only possible with detailed knowledge of controlling factors.*

## 6 CLASSES OF THE ESTUARINE REALM

Estuarine ecosystems are coastal sites dominated by plants and other organisms that are tolerant of wet, brackish soils, and are found at the interface of a freshwater source and marine environment. These ecosystems are affected by occasional or diurnal tidal inundation. Estuarine ecosystems have similar characteristics to wetland ecosystems, with the additional influence of diurnal fluctuations in the water table and variable salinity. The environmental gradients describing site variation in this realm are (1) the degree of tidal flooding, which is closely related to height above mean tide level, and (2) the degree of freshwater influence. Some site associations of the Estuarine Realm are described by MacKenzie and Moran (2004). Photographs of some ecosystems representing each estuarine class are presented in Figure 17.

17a

17b

17c

**FIGURE 17** *Estuarine Realm.*

*17a (Em) Lyngbye's sedge (*Carex lyngbyei*) marshes are one of the most common estuarine ecosystems in British Columbia.*

*17b (Em) Dwarf alkaligrass (*Puccinellia pumila*) occurs where there is prolonged saltwater flooding in northern estuaries.*

*17c (Ed) Estuarine meadows are common in larger estuaries at higher elevations.*

**Estuarine Meadow Class (Ed)**

Estuarine meadows occur in the high intertidal zone of estuaries, where tidal flooding occurs less frequently than daily and is tempered by freshwater mixing. Species composition is relatively diverse, typically with a mix of graminoids and forbs.

**Estuarine Marsh Class (Em)**

An estuarine marsh is an intertidal ecosystem that is flooded diurnally and has simple communities dominated by salt-tolerant emergent graminoids and succulents. These marshes occur in the middle to upper tidal zones of estuaries where saltwater influences predominate.

**Estuarine Tidal Flat Class (Et)**

Estuarine tidal flat sites are intertidal ecosystems dominated by benthic/burrowing fauna and macroalgae. These ecosystems occur in the mid to lower tidal zones of estuaries, where freshwater and salt water mix. Sites are flooded and exposed with most tidal cycles. Large flats of silts, sands, or pebbles are common.

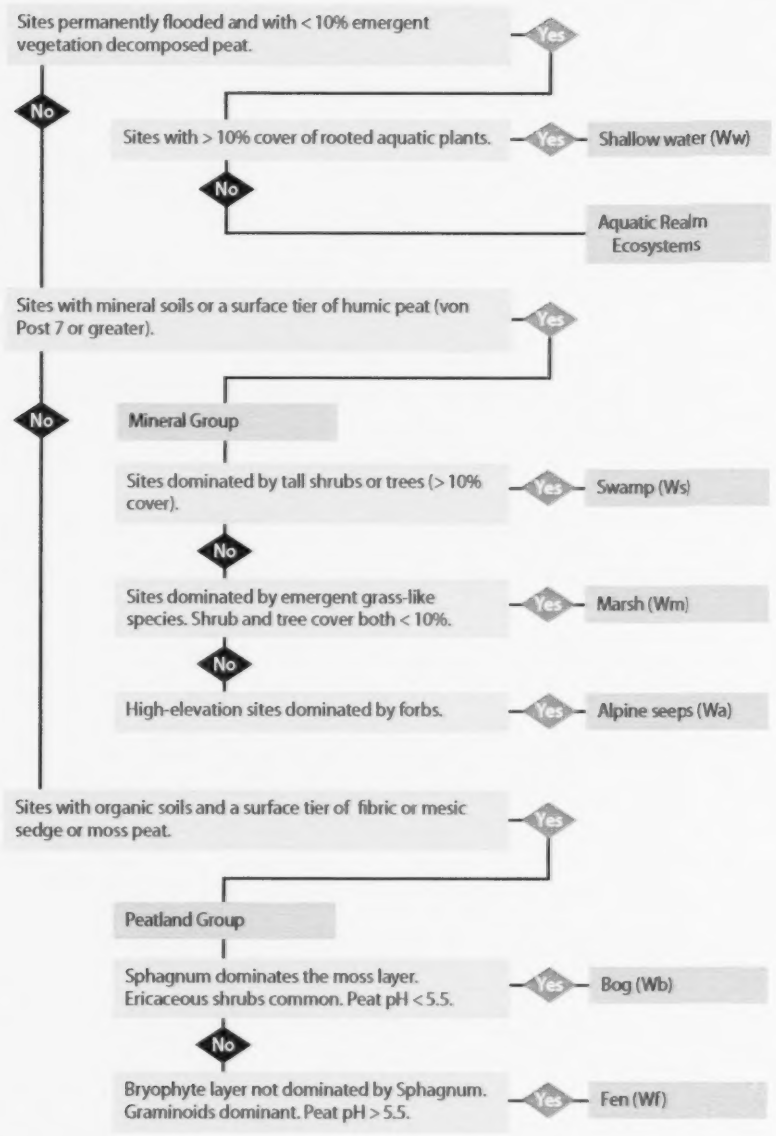



**FIGURE 18** *Key to wetland classes.*

## 7 CLASSES AND GROUPS OF THE WETLAND REALM

Wetlands are ecosystems where soils are water-saturated for a sufficient length of time such that excess water is the principal determinant of vegetation and soils development. Wetlands have a relative abundance of hydrophytic (wetland-adapted) species in the plant community. The stability, mobility, and chemical composition of the water table are the dominant environmental variables affecting wetland ecosystems. Some common site associations of the Wetland Realm in British Columbia are described by MacKenzie and Moran (2004). Photographs of some ecosystems representing each wetland class are presented in Figure 19.

### 7.1 Peatland Group

Stable, high water tables promote peat accumulation and ecosystems with a high cover of bryophytes. Bog and fen ecosystems form under these conditions. Deep, poorly decomposed peat accumulations derived largely from mosses and sedges are typical.

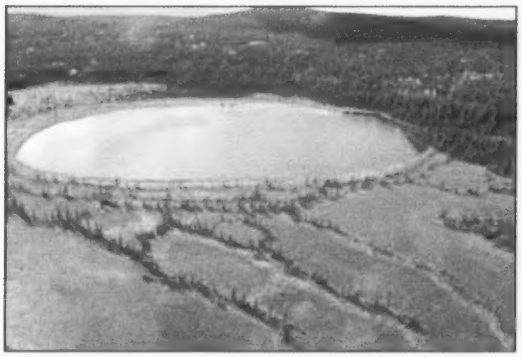
**Bog Wetland Class (Wb)**
Bogs are shrubby or treed, nutrient-poor peatlands with distinctive communities of ericaceous shrubs and hummock-forming *Sphagnum* species adapted to highly acid and oxygen-poor soil conditions. Bogs develop in basins where peat accumulation has raised the wetland surface above groundwater flow, or, less commonly, on hillslopes where groundwater is very low in dissolved nutrients (e.g., flows from granitic parent material).

**Fen Wetland Class (Wf)**
Fens are peatlands where groundwater inflow maintains relatively high mineral content within the rooting zone. These sites are characterized by non-ericaceous shrubs, sedges, grasses, reeds, and brown mosses. Fens develop in basins, lake margins, river floodplains, and seepage slopes, where the water table is usually at or just below the peat surface for most of the growing season.

### 7.2 Mineral Wetland Group

Wetland ecosystems with more dynamic hydrology are more conducive to lush vegetation development. These ecosystems may have considerable subsurface water flow or distinct vertical fluctuations in the water table. These types of sites often have few bryophytes because of competition with vascular vegetation or prolonged submergence. Marshes, swamps, shallow waters, and alpine wetlands may be underlain with peat, but, if it occurs, well-humified peat composed of vascular plant remains.

**Marsh Wetland Class (Wm)**
A marsh is a shallowly flooded mineral wetland dominated by emergent grass-like vegetation. A fluctuating water table is typical in marshes, with early-season high water tables dropping through the growing season. Exposure of the substrate in late season or during dry years is common. The substrate is usually mineral, but may have a well-decomposed organic veneer derived primarily from marsh emergents. Nutrient availability is high (eutrophic to hyper-eutrophic) due to circum-neutral pH, water movement, and aeration of the substrate.



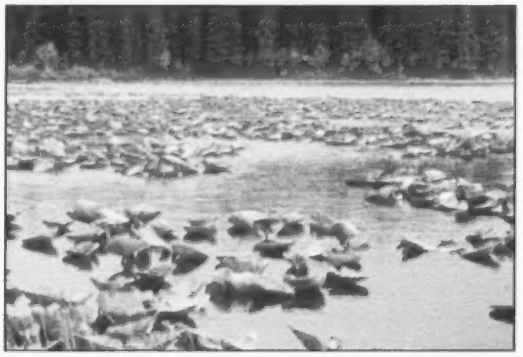
19a

19b

19c

19d

19e



19f

**FIGURE 19** *Wetland Realm (W).*

*19a Wetlands on the landscape are commonly comprised of several wetland associations reflecting internal hydrological gradients and processes.*

*19b (Wm) Marshes are productive ecosystems in the flooded fringes of lakes, slow rivers, and ponds.*

*19c (Wb) Peat mosses and ericaceous shrubs with stunted trees are typical of bogs in British Columbia.*

*19d (Ws) Swamps can be shrub or tree dominated. Mounded microtopography often influences vegetation.*

*19e (Wf) Fen ecosystems are common in British Columbia. Sloping fens like this one occur at high elevations where continual seepage maintains excessive moisture and nutrient inputs.*

*19f (Ww) Shallow water wetland ecosystems occur in waters that are shallow but too deep for marsh ecosystems yet support rooted aquatics. Yellow pond-lily (*Nuphar lutea*) is one of the most common species.*

*19g (Wa) Mountain marsh-marigold (*Caltha leptosepala*) seeps occur along small springs and rivulets in alpine environments.*

*19h (Wa) Mossy seeps are more common on cold aspects, at higher elevations, or in snow accumulation areas.*

*19i (Wb) Bog ecosystems create a mosaic of communities collectively know as "blanket mire" on sloping terrain in the hyperoceanic environments of the west coast of British Columbia (Prince Rupert).*

19g

19h

19i

**FIGURE 19** *Wetland Realm (W) continued.*

**Swamp Wetland Class (Ws)**
A swamp is a forested, treed, or tall-shrub, mineral wetland dominated by trees and broadleaf shrubs on sites with a flowing or fluctuating, semipermanent, near-surface water table. Tall-shrub swamps are dense thickets, while forested swamps have large trees occurring on elevated microsites and lower cover of tall deciduous shrubs. Both types of swamps have abundant available nutrients from groundwater and often have surface standing water. Swamps may be underlain with peat, but it is well decomposed, woody, and dark. Tree and shrub subclasses can be recognized.

**Shallow-water (Aquatic) Wetland Class (Ww)**
Aquatic wetlands are shallow waters dominated by rooted, submerged, and floating aquatic plants. These communities are always associated with permanent still or slow-moving water bodies, such as shallow potholes or deeper ponds and lakes. Shallow-water sites are usually permanently flooded; rarely they may become exposed during extreme drought years. Shallow-water communities most commonly occur where standing water is less than 2 m deep in midsummer. Aquatic plants may root in mineral soils or in well-humified sedimentary peat.

**Alpine Wetland Class (Wa)**
Wet, high-elevation, high-latitude ecosystems occur that do not clearly fit any of the wetland classes of the Canadian Wetland Classification System (NWWG 1988). These ecosystems occur on seeps and saturated flats that have

site characteristics similar to lower-elevation swamps, but because of the constraints of cold climate, they support low-stature vegetation dominated by dwarf willows, forbs, and/or mosses. Sites may be underlain with mineral or very thin organic horizons; peat formation is limited because of low rates of accumulation. Permafrost may occur in some cases.

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